

# Thermoplastic matrix selection based on entropy method for importance weight of criteria

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**ABSTRACT** – The purpose of this study is to determine the importance weight of criteria for thermoplastic matrix selection that need to be considered in fibre metal laminate fabrication for car front hood using entropy method, where the information implied using the linguistic terms. The results showed that the tensile strength, impact strength and density are the essential criteria that need to be considered.

## 1. INTRODUCTION

With the high production of carbon dioxide (CO<sub>2</sub>), vehicles are the main source of the air pollution. It is a primary product of combustion and, for this reason, its production is directly connected to fuel consumption and, consequently, to vehicle weight. Hence, to reduce the CO<sub>2</sub> gas emission, the reduction of vehicle weight is highly recommended [1], and one of the strategy is by reducing the front hood weight. Front hood is the broad piece of metal that gives access to the engine compartment. It has an outer and inner panel. The external panel is the hood skin, while the internal panel is the insulator.

To reduce the weight of the front hood the use of fibre metal laminate has been considered which apart from their potential to be lightweight, FML resistance to localized blast events can improve human safety in mass transit and defense applications [2]. Fibre metal laminate is a combining the suitable properties of layering metals with fibre reinforced composites which are bonded by an adhesive layer. One of the familiar adhesive layer is thermoplastic matrix. Mansor et al. [3] used Multiple Attribute Decision Making (MCDM) methods to select thermoset matrix for automotive bumper beam.

Entropy is the most common method used in MCDM and it was introduced as a new concept of information theory. It could generate objective weight and often used for assessing weight with other MCDM method such as TOPSIS, AHP, etc. Entropy also can be combined with multiple MCDM method as it has been used by Jovanovic et al. [4] to evaluate the significance of environmental impacts with multiple methods AHP, AHP Entropy, TOPSIS, VIKOR and Entropy VIKOR. According to Zhou and Guo [5], combination of subjective weighting method (linguistic ratings) and objective weighting method (entropy method) could measure information implied in the index data and consider the essential information. The combination also

can embody the conscious tendencies of decision makers.

It is well known that the entropy method is commonly used to determine weight of criteria in any field. Therefore, the aim of this study is to determine the importance weight of criteria for thermoplastic matrix selection that need to be consider in fibre metal laminate fabrication for car front hood using entropy method.

## 2. RESEARCH METHODOLOGY

For this study, linguistic rating terms and corresponding fuzzy numbers used are as in Table 1.

Table 1 Linguistic terms and corresponding fuzzy numbers.

Linguistic variable	Fuzzy number
Not important	(0.0, 0.0, 0.1)
Low importance	(0.0, 0.1, 0.3)
Slightly important	(0.1, 0.3, 0.5)
Fair	(0.3, 0.5, 0.7)
Medium important	(0.5, 0.7, 0.9)
Important	(0.7, 0.9, 1.0)
Very important	(0.9, 1.0, 1.0)

### 2.1 Entropy method

The entropy method is capable of being deployed as an objective weight calculation where:

$$X = [X_1, X_2, \dots, X_n] \quad (1)$$

The aggregate weight for each criterion  $W_j$  calculated as follow:

$$X_{ij} = \frac{1}{n} \left( \sum_{e=1}^n X_{ij}^e \right), i = 1, 2, \dots, m \quad (2)$$

The decision matrix need to be normalized to gain projection value of each criterion  $C_j (j = 1, 2, \dots, n)$ :  $P_{ij}$

$$P_{ij} = \frac{x_{ij}}{\sum_{j=1}^m x_{ij}} \quad (3)$$

After normalization, the entropy value  $e_j$  calculated as,

$$e_j = -k \sum_{j=1}^n P_{ij} \ln P_{ij} \quad (4)$$

$k$  is constant, let  $k = (\ln(m))^{-1}$  The degree of divergence  $d_i$  of the basic information of each criterion calculated as,

$$d_{ij} = 1 - e_j \quad (5)$$

The higher the  $d_j$  is, the more important the criterion  $C_j$  is for the problem.

The objective weight for each criterion can be obtain,

$$W_j = \frac{d_j}{\sum_{k=1}^n d_k} \quad (6)$$

### 3. RESULTS AND DISCUSSION

Table 2, Table 3 and Table 4 summarized the overall scores based on the entropy method for the importance of thermoplastic matrix criteria that need to be highly consider on the fibre metal laminate fabrication for car front hood. Criteria that involved in the selection are C1 (tensile strength), C2 (stiffness), C3 (elongation), C4 (impact strength), C5 (density), C6 (water absorption) and C7 (cost).

Table 2 Importance weight of criteria assessed by decision maker.

Criteria	D1	D2	D3
C1	(0.9,1.0,1.0)	(0.9,1.0,1.0)	(0.9,1.0,1.0)
C2	(0.9,1.0,1.0)	(0.7,0.9,1.0)	(0.9,1.0,1.0)
C3	(0.5,0.7,0.9)	(0.5,0.7,0.9)	(0.5,0.7,0.9)
C4	(0.9,1.0,1.0)	(0.9,1.0,1.0)	(0.9,1.0,1.0)
C5	(0.9,1.0,1.0)	(0.9,1.0,1.0)	(0.9,1.0,1.0)
C6	(0.7,0.9,1.0)	(0.9,1.0,1.0)	(0.7,0.9,1.0)
C7	(0.9,1.0,1.0)	(0.9,1.0,1.0)	(0.7,0.9,1.0)

Table 3 Aggregation, normalization and decision maker's weight for each criterion.

Criteria	$X_{ij}$	$P_{ij}$	$\tilde{W}$
C1	(0.9,1.0,1.0)	0.967	0.1519
C2	(0.833,1.967,1.0)	0.933	0.1465
C3	(0.5,0.7,0.9)	0.7	0.1099
C4	(0.9,1.0,1.0)	0.967	0.1519
C5	(0.9,1.0,1.0)	0.967	0.1519
C6	(0.767,0.933,1.0)	0.9	0.1414
C7	(0.833,0.833,1.0)	0.933	0.1465

Table 4 Entropy value, degree of divergence and objective weight for each criterion.

Criteria	$e_j$	$d_j$	$W_j$
C1	0.8266	0.1734	0.1721
C2	0.8429	0.1571	0.1559
C3	0.9690	0.031	0.0307
C4	0.8266	0.1734	0.1721
C5	0.8266	0.1734	0.1721
C6	0.8580	0.142	0.1409
C7	0.8249	0.1571	0.1559

The larger value indicates the important criteria [6]. Based on the results, criteria 1, 4 and 5 have the highest value of weight compared to the other criteria. Second criteria that need to be consider are criteria 2 and 7. While criteria 6 and 3 are at the lowest importance rank.

### 4. CONCLUSIONS

As a result, through entropy method, it revealed that the three criteria; tensile strength, impact strength and density are the essential criteria that need to be consider during the selection of the thermoplastic matrix for fibre metal laminate fabrication for car front hood. It is crucial to identify the importance weight of criteria before developing any product to prevent failure during fabrication.

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